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FOREST PRODUCTS LABORATORY

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DRYING AND CONDITIONING GLUED JOINTS

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In order to obtain strong joints and to prevent warping, checking, sunken joints, and other defects in the finished article, it is essential that wood after gluing be brought to the moisture content most suitable for the subsequent use of the article and that the moisture be evenly distributed throughout.

The common aqueous glue solutions that are used in gluing wood add considerably to the moisture content of the wood, and frequently effect an uneven distribution of moisture within the construction. Table 1 shows the calculated percentages of moisture added to wood in gluing certain types of construction with different glue mixtures and spreads. The table is based on the assumption that the wood absorbs all of the water added by the glue. This is not strictly correct, since some of the glue squeezes out of the joints and some water evaporates during the pressure period. The calculated percentages, however, are reasonably close to the results obtained in actual gluing.

Conditioning Glued Thick Stock

When the moisture increase in the wood is small, as in thick laminations dried to a suitable moisture content before gluing, only conditioning to a uniform moisture content is necessary.

Sunken joints are common defects in the manufacture of thick edge-glued lumber; they are caused by surfacing the stock too soon after gluing. The wood at the joint absorbs more water from the glue than the rest of the piece and therefore swells more. If the piece is surfaces before this excess moisture is distributed, more wood is removed along the joints than at intermediate points. Then, during subsequent drying and conditioning, greater shrinkage occurs at the joints than elsewhere, and permanent depressions are formed. Such depressions along the glue line may show very conspicuously in the finished panel when viewed under a side light. To avoid sunken joints in edge-glued lumber 1 inch thick it should be piled on stickers and dried for a period of 2 days in a kiln at 100° F., for 5 to 7 days at 70° F.

Drying Plywood

It is necessary to dry a part of the glue moisture from plywood and veneer panels. For example, assuming a moisture content of 3 percent in the veneer and an increase of 14 percent from the glue, the panels

Table 1.--Percentages of moisture added to wood in gluing.[1]

Number of plies or laminations	Face	Crossband	Core	Total thickness unsanded	Percentage of moisture added by -- Glue mixed 1 to 2-1/4, if spread 60 square feet[2]	Glue mixed 1 to 2, if spread 50 square feet[2]	Glue mixed 1 to 1-3/4, if spread 30 square feet[2]
				Inches	Percent	Percent	Percent
3	1/40-inch yellow birch	do	1/40-inch yellow birch	3/40	30.5	32.5	47.3
3	1/28-inch yellow birch	do	1/20-inch yellow birch	17/140	18.8	20.1	29.3
3	1/20-inch hard maple	do	1/20-inch hard maple	3/20	15.5	16.5	24.1
3	1/16-inch yellow birch	do	1/16-inch yellow birch	3/16	12.2	13.0	19.0
3	do	do	1/16-inch basswood	3/16	14.0	15.0	21.9
3	1/16-inch basswood	do	do	3/16	20.2	21.6	31.5
3	1/16-inch red gum	do	1/12-inch red gum	5/24	14.1	15.1	22.0
3	1/20-inch red gum	do	3/16-inch red gum	23/80	10.2	10.9	15.9
3	1/8-inch Douglas fir	do	1/8 Douglas fir	3/8	7.5	8.0	11.7
5	1/16-inch yellow birch	1/12-inch yellow birch	1/16-inch yellow birch	17/48	12.9	13.8	20.1
5	1/20-inch red oak	1/20-inch yellow poplar	3/16-inch yellow poplar	31/80	15.8	16.9	24.6
5	(1/20-inch mahogany) (1/20-inch red gum)	do	5/8-inch chestnut	33/40	7.9	8.4	12.3
5	1/28-inch black walnut	1/20-inch red gum	15/16-inch red gum	621/560	5.3	5.6	8.2
5	1/8-inch white oak (quartered)	1/16-inch yellow birch	23/16-inch white pine	29/16	3.6	3.8	5.5
9	1/8-inch yellow birch	1/8-inch yellow birch	1/8-inch yellow birch	9/8	8.1	8.7	12.6
10	3/4-inch yellow birch	All plies or laminations parallel	do	7-1/2	1.4	1.5	2.1

[1] Percentages calculated from average weights (oven-dry based on volume when air-dry) of various species as given in Table 3 of Tech. Rpt. No. 84 of the Natl. Advisory Committee for Aeronautics (18) or Table 2 of U. S. Dept. Agr. Bul. 556 (37). In the calculations it is assumed that all the surplus moisture added by the glue is absorbed by the wood.

[2] Single glue line per pound of dry glue.

when removed from the clamps or press would contain about 17 percent of moisture. Such percentages are common in many types of plywood immediately after gluing. For use in cabinets, in furniture, or in the interior of buildings more than one-half of this moisture should be removed before the panels are ready to be put into the finished article. For use outdoors or in unheated buildings, plywood containing about 12 percent moisture will generally prove satisfactory. Where veneer is glued over a lumber core, the increase in moisture content of the whole panel at the time of removing the panels from the press is not so large as with thin plywood. However, in thick core panels the moisture from the glue is largely confined to the outside of the core and to the veneer. Therefore, the excess moisture of these parts is as great as in thin plywood and must be dried out or allowed to equalize through the core.

If thick cores (1-1/2 inches) are dried to a low moisture content before gluing, the water added in gluing the veneer onto the core may not bring the whole panel above 7 percent moisture content. Under such a circumstance, the panels are sometimes stacked solid in piles and allowed to condition. This requires a long conditioning period, and the absorption of moisture by the core after the crossbands have been glued to it subjects the whole panel to severe stresses.

A better and rapidly increasing practice for conditioning thick-core panels which contain excessive moisture is to place the panels on stickers and allow them to dry in panel kilns or in factory work-rooms. This practice allows the excess moisture to be dried from the panel faces where it is largely concentrated and does not necessitate drying the thick-core stock to an extremely low moisture content before gluing. Panel kilns permit more rapid drying than factory workrooms, give a better means for controlling the conditions during drying, and save factory space.

In panel kilns it is very easy to dry most 3-ply and 5-ply panels satisfactorily in 24 hours. Thick stock and low drying temperatures increase the required drying time. Results of tests at the Forest Products Laboratory in panel kilns show that under normal conditions the moisture added in gluing 3-ply panels, 3/16 of an inch thick, can be dried out satisfactorily in from 8 to 16 hours. These tests also indicate that the desired essentials in drying can be met by maintaining a constant temperature and relative humidity throughout the drying. To save time in such kiln operations it is advantageous to maintain conditions which correspond to a moisture content slightly below that to which the panels are to be dried.

Table 2 shows several combinations of temperatures and relative humidities, which will bring the stock to approximately the desired moisture content but which will not allow an appreciable amount of drying beyond this point.

Panels are usually open piled on strips called stickers. The stickers should be made from dry straight-grained wood, entirely free

Table 2.--Combinations of temperatures and relative humidities suitable for drying plywood panels to moisture-content values of 6 to 12 percent, inclusive.

Moisture content desired, percent	Relative humidity for use with stated temperature[1]						
	70° F.	80° F.	90° F.	100° F.	110° F.	120° F.	140° F.
6	19	19	20	21	22	24	26
7	24	26	27	28	29	31	34
8	30	31	32	33	35	37	41
10	43	44	45	46	48	50	53
12	55	56	57	58	59	61	65

[1] The relative humidities shown for the lower temperatures and moisture-content values are obtainable ordinarily only during the winter season. Where a low moisture content is necessary during warm, humid weather, it can be obtained by raising the temperature.

from stain or decay. Moreover, the stickers should be dressed to a uniform thickness. Seven-eighths by 1-1/4 inch stickers should be used in drying the usual run of panels.

In loading a kiln truck stickers should be placed at the extreme ends of the panel and the intervening space so divided that the distance between stickers will not exceed 18 inches. Where there is danger of warping the stickers may be spaced a foot apart. It is important that the stickers in each tier be placed in vertical alignment on solid foundations to prevent the panels from sagging. The possibility of warping in the upper panels may be further reduced by placing a cover board on stickers on top of the pile. Sometimes the piles are weighted, but experiments indicate the application of pressure to panels during drying does not reduce warp as much as commonly thought. Whenever practicable plywood should be so piled as to provide flues from the top to the bottom of the load in order that air may readily move in a vertical plane through it.

Drying panels to an excessively low moisture content materially increases warping, checking, opening of joints, and other defects. Tests show that the amount of warping on 3-ply veneer panels is approximately proportional to the percentage of moisture removed from the panel in drying.

In a few instances plywood has been dried on mechanical veneer driers and on hot-plate presses. These methods, however, have been confined to plywood of a high moisture content, which was glued with water-resistant glue. Plywood dried in this way is usually comparatively thin and not of the highest quality. The high temperatures and the pressures used in these methods have a molding effect on the wood and to some extent thus prevent face checking and warping. The use of mechanical driers and hot-plate presses results in quick drying, but involves more expensive equipment than the other methods.